Summary of Findings

Low Flow Nutrient Loads

The median low-flow mass loads of nutrients from each of the non-tidal watersheds (Brandywine, Red Clay, White Clay, and Christina) are summarized in Table 13. The drainage areas covered for each watershed are reported, and the median mass loads per unit drainage area were calculated for comparison between watersheds. In terms of magnitude, the Brandywine contributes the largest loads of nitrogen and phosphorus, followed by the Red Clay, White Clay, and Christina. However, in terms of mass loads per unit area, the Red Clay Creek has significantly higher phosphorus loads and slightly greater nitrate-nitrogen loads than the Brandywine. In particular, the Red Clay watershed above Marshalls Bridge has the highest phosphorus and nitrogen loads per unit area. The White Clay and Christina River watershed contribute phosphorus loads per unit area approximately an order of magnitude less than the Red Clay Creek. However, the upper watershed of the White Clay Creek also has a high nitrate loading per unit area, which is likely due to nitrate contamination of the groundwater aquifer.

Reserved for Table 13

Table 13. Summary of Median Nutrient Loads Throughout the Christina Watershed

Watershed/Station		Drainage Area (sq mi)	Median Mass Load				Median Mass Load per Unit Drainage Area			
			TP (lb/d)	SOP (lb/d)	NO3-N (lb/d)	NH3-N (lb/d)	TP (lb/sq mi-d)	SOP (lb/sq mi-d)	NO3-N (lb/sq mi-d)	NH3-N (lb/sq mi-d)
Brandywine										
East Br	Above Downingtwon	60.6	3.5	0.6	138	2.3	0.06	0.01	2.3	0.04
	Below Downingtown	89.9	38.1	23.8	592	6.3	0.42	0.27	6.6	0.07
	Wawaset	124.0	60.0	39.1	1027	11.9	0.48	0.32	8.3	0.10
West Br	Coatesville	45.8	13.5	10.2	205	2.3	0.29	0.22	4.5	0.05
	Modena	55.0	45.1	21.9	468	5.7	0.82	0.40	8.5	0.10
	Wawaset	134.0	33.0	23.5	865	5.8	0.25	0.18	6.5	0.04
Mainstem	Chadds Ford	287.0	67.4	55.3	2041	14.6	0.23	0.19	7.1	0.05
	Wilmington	314.0	75.8	54.1	1498	30.1	0.24	0.17	4.8	0.10
Red Clay	Marshalls Br	28.3	32.9	31.7	351	2.0	1.16	1.12	12.4	0.07
	Woodale	47.0	30.9	27.2	260	3.0	0.66	0.58	5.5	0.06
	Stanton	52.4	25.2	20.1	275	2.4	0.48	0.38	5.2	0.04
White Clay	Stroud Res.	2.5	0.2	0.02	20	0.1	0.08	0.01	7.8	0.05
	Strickersville	59.2	14.0	9.0	404	2.9	0.24	0.15	6.8	0.05
	Above Mill Cr	89.1	4.9	2.1	136	3.3	0.05	0.02	1.5	0.04
Christina	East Br. Above Rt 273	3.2	0.1	0.04	6	0.7	0.02	0.01	2.0	0.21
	West Br. at Rt 2	5.3	0.4	2.2	9	0.5	0.08	0.42	1.7	0.09
	Cooch's Br.	21.1	0.9	0.4	31	0.7	0.04	0.02	1.5	0.03
	Muddy Run	8.7	0.6	0.2	1	1.0	0.07	0.02	0.1	0.12
	Smalleys Dam	46.8	2.6	0.6	25	2.6	0.06	0.01	0.5	0.06

Water Quality Criteria Excursions

The review and assessment of low flow water quality data for the Christina Watershed found several reaches to be in violation of the governing water quality standards for DO and pH. The locations and nature of the water quality problems are summarized below.

Frequent violations of the maximum pH criteria were observed on the East Br. Brandywine River below Downingtown and West Br. Brandywine at Modena. Occasional excursions of maximum pH criteria were observed at the Chadds Ford station on the mainstem Brandywine, but these excursions may be related to the conditions in the East and West Branches. The pH excursions on the Brandywine appear to be related to photosynthetic activity since the daily variation in pH closely follows the variation in DO. The change in pH is caused by the uptake of carbon dioxide and nutrients from the water column by algae and plants during photosynthesis. Since the growth of plants and algae are controlled by nutrient concentrations, nutrient loads to these waters may need to be reduced. In addition, earlier studies (Davis, 1997) indicate that phosphorus is the controlling nutrient for these segments.

Frequent excursions of minimum and daily average DO criteria occur in the West Branch Red Clay Creek below Kennett Square. These excursions are related to organic and nitrogenous wasteloads from the Kennett Square wastewater treatment plant discharge (Davis, 1997).

Excursions of daily average and minimum DO criteria occur in the tidal Christina River during critical low flow, high water temperature conditions. High phytoplankton biomass levels, as indicated by chlorophyll-a and pheophyton concentrations, were found to accumulate in the tidal river during these times. The accumulation of the phytoplankton biomass may be due to either growth within the tidal river and/or transport of phytoplankton biomass from inland tributaries, which may include Churchmans Marsh. If additional studies indicate significant growth of phytoplankton within the tidal river, it is likely that reductions in nutrient loads to tidal river will be necessary.

Changes in Water Quality Conditions

Many of the stations analyzed in the Christina indicated fairly stable water quality conditions during low flow conditions in terms of nutrients and dissolved oxygen. No significant changes were found for the stations in the Red Clay Creek and Christina River. The White Clay Creek data indicated a significant reduction in soluble ortho-phosphorus and nitrate-nitrogen concentrations and mass loads for the station downstream of Newark (above the confluence with Mill Creek).

The most significant and noticeable changes occurred in the East and West Branches of the Brandywine River during the period of 1988-1992. Dissolved oxygen concentrations in both of these segments increased significantly during this period, which is probably related to reductions in wasteloads of organic and nitrogenous oxygen demand from the major wastewater treatment facilities in the Downingtown and

Coatesville areas. Prior to 1988, excursions of the minimum DO criteria frequently occurred. Since that time, no DO criteria violations have been recorded at the continuous monitors operated by USGS. During the same time period, the pH levels in both branches increased to levels exceeding the maximum pH criteria as was discussed above. Soluble ortho-phosphorus concentrations and mass loads decreased in the East, West, and mainstem branches during the early 1990's which is probably related to upgrades at the major wastewater treatment facilities. Nitrate nitrogen concentrations and mass loads increased in the East Branch and mainstem during the early 1990's.